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THE EVALUATION OF DEODORANTS FOR USE IN AIRCRAFT CHEMICAL TOILETS

L. R. Setter, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

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THE EVALUATION OF DEODORANTS FOR USE IN AIRCRAFT CHEMICAL TOILETS

By

L. R. Setter
C. E. Whitfield

FINAL REPORT

To

Aero Medical Laboratory
Wright Air Development Center
Wright-Patterson Air Force Base, Ohio

On

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Details of illustrations in
this document may be better
studied on microfiche

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Robert A. Taft Sanitary Engineering Center

Cincinnati, Ohio

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ABSTRACT

The immediate objective of this study was to select deodorant chemical formulations best suited for use in aircraft chemical toilets, with the ultimate objective of developing a group of minimum performance characteristics for deodorant chemicals acceptable to the U. S. Air Force.

An air dilution technic obtaining threshold odor values leading to odor control factors was found to be the most satisfactory method for deodorant evaluation. This technic utilized an osmometer developed especially for the purpose. Olfactory anaesthesia and the masking power of deodorants are two other important parameters that can be readily evaluated with the osmometer. These three indices along with ancillary tests on shelf stability, corrosivity to aluminum metal, suitability of packaging, etc. would provide the necessary minimum performance characteristics exclusive of an evaluation of the disinfecting power.

THE EVALUATION OF DEODORANTS FOR USE IN AIRCRAFT CHEMICAL TOILETS

By L. R. Setter and C. E. Whitfield

INTRODUCTION

The Military Air Transport Service and other Air Force commands have expressed their dissatisfaction with deodorant chemicals currently used to service aircraft chemical toilets.[1] Recognizing the deficiencies in waste disposal aboard aircraft, the inadequacies of existing test procedures, and the urgent need to establish performance criteria for deodorant chemicals, the Aero Medical Laboratory of Wright Air Development Center sponsored a program of research with the Robert A. Taft Sanitary Engineering Center, Public Health Service, Department of Health, Education, and Welfare to investigate performance evaluations of deodorants.

The immediate objective of this program was to select deodorant chemical formulations best suited for use in aircraft chemical toilets, with the ultimate objective of developing a group of minimum performance characteristics for deodorant chemicals acceptable to the U. S. Air Force.

Deodorant chemicals for chemical toilets may be effective for prevention of nuisance odors by:

1. Physical or chemical interaction with the malodorous matter, resulting in deodorization.
2. Prevention of odor production by potentially malodorous matter.
3. Masking of malodor by deodorant odor.
4. Production of olfactory anaesthesia.

For deodorants used aboard aircraft, actions 1 and 2 above are considered important desirable characteristics. Actions 3 and 4, however, are important undesirable characteristics, because the aircraft personnel should remain able to detect any air contaminants that might be toxic or might indicate fire danger or the malfunctioning or failure of various aircraft equipment.[2] Thus, especially aboard aircraft, the deodorant chemical used must not impair olfaction or mask any alarm odors.

Many deodorant formulations may contain one or more chemicals that possess each of the above characteristics. An evaluation of deodorants for aircraft use should measure both the desirable and the undesirable characteristics with respect to the control of odor, and should include ancillary evaluation tests with respect to:

(a) Shelf stability of the deodorant under various environmental conditions.

(b) Corrosivity of the deodorant to latrine buckets.

(c) Size, and suitability of dispensing container.

(d) Weight of agent per latrine dose.

The primary objective of this work was to devise procedures for testing odor control efficiency rather than general suitability.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF DEODORANT-CHEMICALS

The physical and chemical characteristics of the 55 deodorant-chemicals submitted for testing are presented in Table 1. The agents are listed by code numbers according to the predominant type of active agent such as peroxides, halogens, heavy metals, phenolics, quaternaries, etc.

PHYSICAL FORM OF UNIT DOSES

The tablets were packaged in screw cap glass bottles or paper cartons. One agent was a liquid enclosed in a metal capsule or envelope and packaged in a bottle. The capsules were unsatisfactory, since leakage was evident. Twenty agents were powders and 23 were liquids in metal or glass containers. All of these agents were given preliminary screening tests even though they were not conveniently packaged for treating individual toilets.

PHYSICAL FORM IN WATER

All but four of the agents were largely dispersed in water at the concentrations used. This dispersibility was considered a desirable property, although effective odor control might be achieved by immiscible floating agents or insoluble agents. Agent No. 510 had the unique behavior of forming a solid jell when about 25 grams of powder was added to a liter of diluted fecal matter.

ODOR OF AGENTS

Seven of the 10 halogenated agents, all six of the phenolic agents, two of the 17 quaternary agents, and eight of the 15 miscellaneous agents had strong odors. Intense odors of agents indicate a likelihood of masking or desensitizing the perception of warning odors, an effect which is considered very undesirable aboard aircraft.

SHELF STABILITY

Shelf stability, or the keeping qualities of a stored formulation, was observed at ambient temperature over a period of 9 months for most agents. Only one agent, No. 103, was unstable. It decomposed with near explosive force, with the evolution of heat. Shelf stability was also observed after storage for six weeks at 40°C and 100 per cent relative humidity. Eleven of the agents underwent physical changes and 503 decomposed. No tests were performed for chemical changes or deterioration that would be revealed by odor control evaluation after suitable environmental storage.

ALKALINITY, pH AND CORROSIVITY OF AGENT TO ANODIZED ALUMINUM

Although new latrine buckets usually have a surface coating, it becomes chipped or worn so as to expose the metal. Therefore it is desirable that the deodorant chemicals be noncorrosive to anodized aluminum. In the corrosivity tests (see Appendix 1), 25 cm^2 of aluminum was exposed to the action of the agent solution. A corrosion rate of 122 to 125 mg./strip/100 days represents the destruction of 5 per cent of the test strip in 120 days. Translation of strip test results to an evaluation of the actual corrosivity of deodorants in latrine buckets would require definition of several other factors such as the thickness of the bucket, the presence of a protecting enamel, and the degree of destruction at which the useful life of the bucket would be considered terminated.

TABLE I

PHYSICAL AND CHEMICAL CHARACTERISTICS OF DEODORANT CHEMICALS

DEODORANT CODE NO.	ACTIVE AGENT	PHYS. FORM IN BULK	PHYS. FORM IN H_2O	ODOR	SHELF STAB.	CHEMICAL CHARACTERISTICS IN WATER: CONC. USED g/l	CORROSION RATE	pH	ALKALINITY (m.e. PER l OR ml) TO P.	ALKALINITY (m.e. PER l OR ml) TO M.O.
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
PEROXIDE COMPOUNDS										
100	$Na_2CO_3 \cdot 3H_2O_2$	PDR	SOL	NO	I	0.8	39	12.7	7.25	11.72
101	$NaBO_2 \cdot H_2O_2$	PDR	SOL	NO	I	0.8	30	9.9	5.0	6.5
102	$Na_4P_2O_7 \cdot 2H_2O_2$	PDR	SOL	NO	II	0.8	11	9.8	2.4	6.1
103	UREA PEROXIDE	PDR	SOL	NO	VIII	0.8	< 2	6.6	-	0.3
HALOGEN COMPOUNDS										
201	p-DICHLOROBENZENE	TAB	INSOL	STR	III	-	-	-	-	-
204	SUBST. CHLOROBENZENE (1)	PDR	SOL*	NO	I	1.6	77	9.8	1.1	63.
205	O-DICHLOROBENZENE	LIQ	EMUL	STR	I	5.7*	10	9.8	0.3	0.4
206	O-DICHLOROBENZENE	LIQ	EMUL	STR	I	0.63	2	7.9	0.1	0.5
207	TRICHLOROMELAMINE	PDR	INSOL	MILD	I	-	-	-	-	-
209	UNKNOWN	TAB	SOL*	STR	-	0.8	< 2	5.8	-	0.7
210	UNKNOWN	TAB	SOL*	STR	-	0.8	< 2	5.4	-	0.1
211	HYPOCHLORITE (2)	PDR	SOL	NO	I	12.6	57	10.9	1.5	2.7
212	UNKNOWN	TAB	SOL*	STR	I	0.8	3	5.6	-	0.1
213	UNKNOWN	TAB	SOL*	STR	I	0.8	2	5.2	-	0.1
214	IODINE COMPLEX (3)	LIQ	SOL	MILD	I	3.1*	4	3.3	-	-
215	IODINE COMPLEX (4)	LIQ	SOL	MILD	I	7.8*	-	3.9	-	-
HEAVY METAL COMPOUNDS										
300	MERCURIC COMP. (5)	PDR	SOL	NO	IV	1.9	24,000	6.6	-	0.1
PHENOLIC COMPOUNDS										
401	ACID CRESYLIC, 87%	LIQ	SOL	STR	-	10*	< 2	9.6	0.3	0.5
402	COAL TAR	LIQ	EMUL	STR	-	126*	< 2	10.2	0.5	0.6
403	PHENYL PHENATE	LIQ	EMUL	STR	-	126*	19	11.4	22.4	27.
404	PINE OIL	LIQ	EMUL	STR	-	31.3*	6	10.6	0.4	0.5
405	ACID CRESYLIC	LIQ	EMUL	STR	-	200*	3	-	-	-
406	ACID CRESYLIC	LIQ	EMUL	STR	I	200*	2	-	-	-
QUATERNARY COMPOUNDS										
500	QUAT (6), 10%	LIQ	SOL	STR	I	73.7*	< 2	5.9	-	TR
501	QUAT (7), 50%	LIQ	SOL	MILD	I	0.8*	< 2	5.8	-	0.1
502	QUAT (8), 50%	TAB	SOL	NO	I	0.25	< 2	8.2	-	2.7
503	QUAT (9), 25%	TAB	SOL	NO	VIII	1.78	< 2	7.2	-	0.1
504	QUAT (8), 99%	PDR	SOL	NO	II	1.0	< 2	5.7	-	0.2
505	QUAT (8), 12%	TAB	SOL	NO	-	4	< 2	8.9	2.3	41.8
506	QUAT (9), 100%	PDR	SOL	NO	I	0.8	4	5.8	-	0.2
507	QUAT (10), 10%	PDR	SOL	NO	I	3.2	15	10.0	4.9	14.6
508	QUAT (11), 10%	PDR	SOL	STR	I	31.3	< 2	6.4	-	TR
509	QUAT (8), 33%	TAB	SOL	NO	I	4.5	3	8.6	TR	2.8
510	QUAT (8)	PDR	JELL	NO	I	25.3	10	7.4	-	-
511	QUAT (10)	PDR	SOL	NO	II	0.8	2	6.8	-	0.3
512	QUAT (14)	PDR	SOL	MILD	IV	10	-	-	-	-
513	QUAT (6), 33%	TAB	SOL	NO	IV	2	6	-	-	-
514	QUAT (12), 50%	LIQ	SOL	NO	I	100*	-	-	-	-
515	QUAT (13), 25 - 50%	LIQ	SOL	NO	V	0.8	-	-	-	-
516	UREA & 1/3 QUAT (13)	PDR	SOL	NO	II	0.8	-	5.4	-	-
MISCELLANEOUS COMPOUNDS										
600	TRIETHYLENE GLYCOL	LIQ	SOL	MILD	VI	1000*	10	7.8	-	TR
601	UNKNOWN	LIQ	SOL	STR	I	500*	4	6.3	-	-
602	UNKNOWN	LIQ	SOL	STR	I	-	-	-	-	-
603	UNKNOWN	LIQ	SOL	STR	I	500*	< 2	6.4	-	-
604	UNKNOWN	CAP	EMUL	STR	I	100*	2	-	-	-
605	UNKNOWN	SPO	-	STR	I	13.8	8	-	-	-
606	UNKNOWN	LIQ	SOL	STR	I	1.8*	< 2	4.6	-	-
607	CHLOROPHYLL	PDR	EMUL	MILD	I	50	< 2	5.9	-	-
608	UREA	PDR	SOL	NO	VII	150	9	9.2	TR	9.2
609	LAURYL METHACROLATE	LIQ	INH	STR	I	100*	< 2	2.8	-	-
610	UNKNOWN	LIQ	SOL	MILD	I	300*	2	8.2	-	TR
611	UNKNOWN	PDR	SUSP	MILD	I	7	62	4.0	-	-
612	UNKNOWN	LIQ	EMUL	STR	I	1.8*	< 2	4.5	-	TR
613	UNKNOWN	LIQ	SOL	NO	I	1000*	5	6.7	-	-
615	UNKNOWN	PDR	SUSP	MILD	I	7	< 2	-	-	-

NOTES FOR TABLE I

COLUMN A:

(1) Mono-benzyl p-dichlorobenzene, 6.4%.

(2) Sodium hypochlorite, 11.5%.

(3) Polyethoxy-poly-propoxy-ethenol iodine, 7.75% and monyl phenylether of polyethylene glycol-iodine (1.6% available iodine).

(4) Monyl phenylether of polyethylene glycol-iodine, 4.5% (0.45% available iodine).

(5) Potassium tetraiodomercuriate.

(6) Di-isobutyl cresoxyethoxyethyl-di-methyl benzyl ammonium chloride.

(7) Tallow tri-methyl ammonium chloride.

(8) P-di-isobutyl phenoxyethoxy ethyl di-methyl benzene ammonium chloride.

(9) Cetyl tri-methyl ammonium chloride.

(10) Di-methyl benzyl lauryl ammonium chloride.

(11) Alkyl tolyl methyl tri-methyl ammonium chloride.

(12) Methyl alkyl benzyl tri-methyl ammonium chloride.

(13) Alkyl di-methyl benzyl ammonium chloride.

(14) Cycloakonium chloride.

COLUMN B:

PDR - powder; TAB - tablet; LIQ - liquid; SPO - sponge; CAP - capsule.

COLUMN C:

SOL - soluble; INSOL - insoluble; SOL[a] - bulk soluble some sediment; EMUL - emulsion; IMM - immiscible; SUSP - suspension.

COLUMN D:

STR - strong odor; NO - no odor; MILD - mild odor of agent as received.

COLUMN E:

Shelf stability of agent after six weeks at 40° C and 100% relative humidity. I - no change; II - caked; III - sublimed; IV - liquefied; V - congealed; VI - separated into layers; VII - solidified; VIII - decomposed rapidly.

COLUMN F:

Concentration in grams *(*ml)* per liter used for chemical tests.

COLUMN G:

Corrosion rate - loss of anodized aluminum from strip 10.3 x 1.3 x 0.1 *cm* (29.5 cm^2) submerged in 30 *ml* of agent solution for 70 to 110 days and expressed in *mg* loss per strip per 100 days.

The orders of corrosivity of the deodorants at the concentrations used in the strip tests are as follows:

Corrosivity, mg./100 days	Deodorants
24000	300
57-77	204, 211, 611
30-40	100, 101
9-20	102, 205, 403, 507, 510
2-6	All others tested

DEODORANT EVALUATION TESTS

There are two general approaches to organoleptic rating of deodorants. One method consists of subjecting malodorous source material to varying concentrations of deodorants for the required time and temperature and then rating the samples according to the degree of objectionable odor reported by a panel of observers. By this method, samples having strong nondisagreeable odors may be rated equal to or better than those having mildly disagreeable odors. Undesirable masking or olfactory desensing agents may rank better than nonmasking or nonaesthetic agents. Usually there is a great disagreement among observers in ranking samples. Lastly, the method is relative and yields nonquantitative results from which it is difficult to prepare unbiased performance specifications.

The other approach, which was selected for this study, is the threshold odor test. In this test, samples of malodorous source materials are treated with deodorant chemicals, and after a suitable time and temperature of incubation the threshold odor of samples with deodorant is compared to the threshold odor of control samples of source material without deodorant. In the present work the threshold point was established using water dilution and air dilution technics.

SOURCE MATERIAL FOR DEODORANT EVALUATIONS

The malodorous material used in these tests consisted of (1) dilute, human feces with or without urine or (2) a mixture of ground chuck meat, eggs, and water seeded with sewage. The samples of untreated source material and of source material containing deodorant were usually incubated for 24 hours at 29°C before determining the threshold odor.

About five dozen deodorant samples were submitted by industry upon invitation from the Aero Medical Laboratory (Appendix II). Many of the deodorants appeared to be nearly identical compounds, varying

principally in concentration of active agent. Only representative samples of similar deodorants were selected for the more rigorous testing of their ability to control odors and their tendency to mask warning odors or cause olfactory anaesthesia.

WATER DILUTION TECHNIC

The preliminary tests were made by the water dilution technic, in which aliquots of sample mother liquor were diluted according to Standard Methods of Water and Sewage Analysis and tested. The method is tedious, time consuming, and is not suitable where a large panel of observers is to be used.

Odor Prevention Tests

A malodorous source material consisting of 95 to 100 grams of ground meat, 12-13 grams of fresh eggs, and 12-13 milliliters of stale sewage per liter of mixture was used in these tests. The fresh source material had a threshold odor (of meat) of 4. Aliquot samples of 200 ml each of source material were treated with various concentrations of deodorant chemical as shown in Table 2. The treated samples and untreated control samples were incubated for 24 hours at 28-29 °C. Several dilutions of each incubated sample were prepared in odor-free water. Each dilution consisted of 200 ml in a 500 ml glass stoppered flask. Two observers then sniffed in sequence the highest to lowest dilution flasks (interspersed with flasks of odor-free water) until they detected a dilution with odor. This dilution is designated as the threshold odor (T.O.) and expressed as the ratio obtained by dividing the total volume of the diluent by the volume of the sample.

The results are presented in Table 2 in terms of an "odor control factor," which is the ratio of the T.O. of the control to the T.O. of the deodorant-treated sample. The last column in the table shows the threshold odor of untreated source material, which varied from 3,000 to 10,000 except in a few tests in which a 48-hour incubation period produced a control T.O. of 50,000 to 70,000. Odor control factors based on 48 hours of incubation should not be compared to those from 24-hour tests.

Deodorants which result in odor control factors of less than 10 are not particularly effective. Table 2 shows that some deodorants were not very effective at the concentrations used, whereas others (Nos. 505, 509, 501, 502, 510, 513, 540, 601, and 101) were quite effective at some concentrations, since odor control factors of 40 to 850 were obtained.

TABLE 2

ODOR CONTROL FACTOR FOR VARIOUS DOSAGES OF CHEMICAL

DEOD. CODE NO.	ACTIVE AGENT** PER CENT	CONCENTRATION OF DEODORANT-CHEMICAL IN GRAMS OR ml PER LITER									T. O. OF CONTROL (THOUSANDS)
		0.1-0.2	0.4-0.6	0.8-1.0	1.5-2.0	3-5	8-10	14-15	20-30	40-60	
OXIDANTS											
100	100			1		1.2	33				5
101	100			1		17	50				5
102	100			1		1.2	1.2				5
HALOGEN COMPOUNDS											
204	6.4	2.0			1.2	2				1.3	10
205	100			1.0			10		0.8		10
206	100		10			10	3				10
207	100					80					10
208	96					0.6					5.6
209	100	1.1		0.5	1	1					5.6
210	100	1.2			1	0.7					5
211	1.7	0.7	50	16							5.6
214	11.5					2.5	75.		1.3	1	5
215	4.5					1.2			0.7		70
PHENOLIC COMPOUNDS											
401	87					2.4				1	5
402	90							0.25			5
404	90			4					0.6		5
405	100	.25		.06		.03					
406	100	2.2		.70		.04					
QUATERNARY COMPOUNDS											
500	40			1.6		1.6		1.1			
501	50		2.3	2		40-80	12		11		3
502	50		1.2	9		600					3
503	25				5	80	20				3
504	99			12	40	50	3-20				5
505	12	40	110	100	850						4
506	100			4	13	13					5
507	10								0.7	5*	4
508	10					1.1			50		10
509	33.3			40	120	600					10
510	100								67		10
513	30		3.0		16	42					
MISCELLANEOUS COMPOUNDS											
600	100			1.7			2.5				5
601			1.4			33				40	5
604		2			17						
606		4.8			0.8		2.6		20		50
612		1.2				5.9					

* ODOR CONTROL FACTOR OF 25 AT A CONC. OF 100 ml/LITER.

** ACTIVE AGENT CLAIMED BY MANUFACTURER

Deodorizing Tests

In the above evaluation of deodorants it was suspected that most of the odor control was achieved by disinfectants which prevented enzymatic or microbial production of odor during the incubation period. It was recognized, however, that deodorants that reacted with odorous components of a source material would be beneficial in controlling the odor of fresh fecal material. In order to test the deodorizing power of deodorants, samples of the synthetic source material were incubated for 24 hours before deodorant chemicals were added. The threshold odor by the water-dilution technic was then determined by two observers within a few hours. The results are presented in Table 3, which shows that since with few exceptions the threshold odor of treated source material was as great as or greater than the threshold odor of the control sample, the tested deodorants were not effective in destroying odors.

TABLE 3. THE DEODORIZING POWER OF DEODORANTS

Deodorant Code No.	Deodorant Dose, g/l	Control sample T.O. = 6250: Deodorant-treated sample T.O.	Control sample T.O. = 6250: T.O. ratio, control/treated
207	5	5,000	1.2
211	0.4	9,300	0.7
214	1*	6,200	1
401	5*	12,500	0.5
501	10	9,300	0.7
502	2	18,300	0.3
504	3	6,250	1
505	2.1	6,250	1
508	62	30,000	0.2
509	1.5	5,000	1.2
		Control sample T.O. = 3100	
600	100*	12,500	0.2
601	50*	6,200	0.5
602	50*	3,100	1
603	50*	6,200	0.5
604	1.5	3,100	1
607	5	2,000	1.5
608	450	1,000	3
609	100*	1,000	3
610	200*	6,200	0.5
611	16.5	3,100	1

* Milliliters per liter.

AIR DILUTION TECHNIC

More extensive testing was made by the air dilution technic[2] utilizing an osmometer for (a) evaluating deodorants used in controlling latrine-bucket odors, (b) determining the odor masking power of deodorants, and (c) determining whether deodorants interfere with the perception of warning odors. The osmometer was developed especially for these tests in order to obtain a wide range of air dilutions. The construction and operation of the osmometer are presented in Appendix III.

Odor Prevention Tests

The deodorant evaluation tests by the water dilution technic were largely exploratory, usually employing two observers and synthetic source material. The tests were repeated on fecal matter for some of the more promising deodorants. The odor panel consisted of 12 to 20 scientific personnel furnished by the Aero Medical Laboratory of Wright Air Development Center. For these tests approximately 6 grams of feces and the required dose of chemical in 200 ml of tap water were incubated at 29° for 20 to 28 hours prior to making the threshold odor determinations. Control samples were diluted 1:10 or 1:20 in order to bring the threshold odor within the range of the osmometer. The results are presented in Table 4.

The results show that the threshold odor determinations usually varied 5 to 20 fold among the panel members. This variation is due to individual differences in odor perception and possibly to the variable incubation period. The median and geometric mean threshold odor values of each test sample were obtained and were usually in fair agreement. The geometric mean was used to calculate the odor control factors. Factor I is the ratio of the geometric mean threshold odor of the control samples on the test day to the geometric mean threshold odor of the deodorant-treated sample.[3] Factor II is the ratio of the 5-day average geometric mean threshold odor of the control samples to the geometric mean threshold odor of a deodorant-treated sample on a single day.

In Figure 1, a block chart of the results listed in Table 4, the T.O. values and deodorizing factors present similar patterns which indicate that the 17 deodorants fall into two or three groups when ranked by effectiveness in controlling odor:

Group 1	Group 2	Group 3
101	506	501
516	511	613
512	608	606
214	507	207
504	211	401
	607	205

TABLE 4. DEODORANT EVALUATION WITH OSMOMETER

Human Excrement Tests, 12-20 May, 1955

Panel = 12 members on May 12 and 20 on May 17-20.

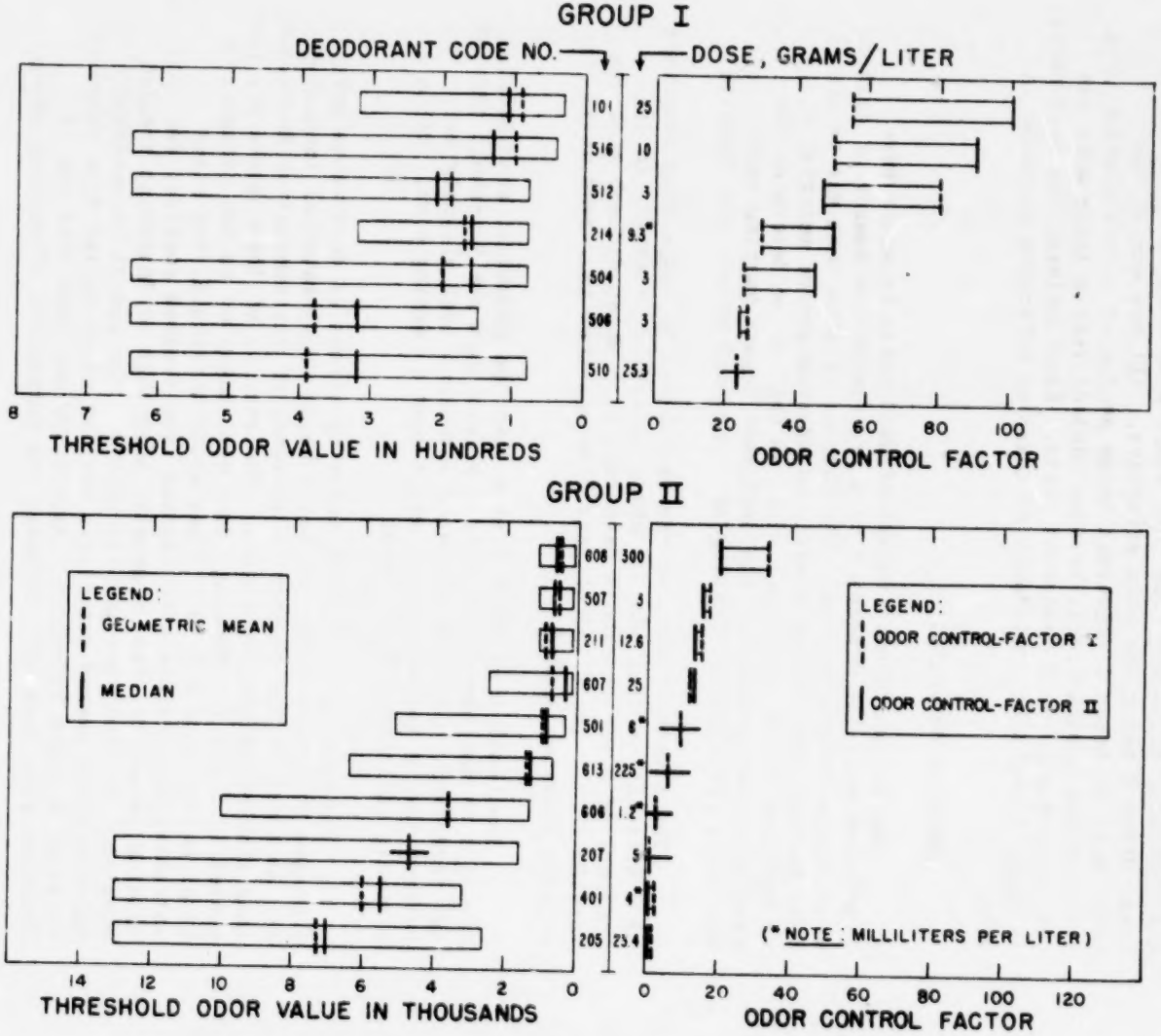
Date	Deodorant Code No.	Deodorant Dose, g/l	Threshold odor values Minimum	Threshold odor values Maximum	Threshold odor values Median	Threshold odor values Geo. mean	Odor-control factors** I	Odor-control factors** II
5/12	Control		720	13,000	4,800	5,000		
	101	25	30	320	110	90	55	100
	214	9.3*	80	320	160	170	30	50
	504	3	80	640	160	200	25	45
	516	10	40	640	130	100	50	90
5/17	Control		3200	51,000	9,100	10,000		
	211	12.6	160	1,300	590	680	15	13
	506	3	150	640	320	380	26	24
	507	3	160	1,300	640	580	17	15
5/18	Control		2000	130,000	5,900	8,500		
	501	6*	320	5,100	910	980	9	9
	606	1.2*	1290	10,000	3,600	3,600	2.4	2.5
	607	25	160	2,500	360	360	12	12.5
5/19	Control		3200	100,000	18,000	15,000		
	205	23.4*	2600	13,000	7,000	7,000	2	1.2
	401	4*	3200	13,000	5,500	6,000	2.5	1.5
	512	3	80	640	210	190	80	47
	608	300	80	1,300	640	450	33	20
5/20	Control		1500	51,000	11,200	9,100		
	207	5	1600	13,000	4,700	4,700	1.9	1.9
	510	25.3	80	640	320	390	23	23
	613	225*	650	6,400	1,300	1,400	6	6

Average of controls (5 days) - - - - 9,000

* Milliliters per liter.

** Odor control Factor I = $\frac{\text{Geometric mean of control}}{\text{Threshold odor of treated sample}}$

Odor control Factor II = $\frac{\text{9,000 5-Day average of controls}}{\text{Threshold odor of treated sample}}$



DEODORANT EVALUATION WITH OSMOMETER

FIGURE I

Calculations of odor control factor I for each panel member were subjected to statistical analysis for tests made on May 17 through May 20. These are represented chiefly by Groups 2 and 3 which are statistically different from each other with respect to effectiveness, Group 2 being the more effective. All but one of the deodorants in Group 1 represent those evaluated in tests which were not analyzed statistically because control sample tests were not run concurrently with deodorant tests. Nevertheless, the deodorants in Group 1 might be considered at least as effective as those in Group 2.

Masking Potential

The threshold odor values of deodorants in water were determined with the osmometer on a representative number of deodorants at use concentrations. The purpose of this test was to see what part of the T.O. of treated malodorous source material could be ascribed to the deodorant odor, as well as to determine the masking characteristic of the deodorant toward warning odors, such as vapors from hot lubricating oil, scorched paint, and gasoline.

The masking potential was determined by subjecting observers to a distinct warning odor at above threshold intensity in the presence of a sub-threshold deodorant odor which did not mask the warning odor. The deodorant gas flow was then increased until the warning odor was masked.

The results in Table 5 show that the geometric mean masking dilution is the same as or slightly less than the threshold odor of the deodorant. In other words, a deodorant odor slightly more intense than a threshold odor would mask a warning odor. Table 6 presents additional T.O. tests.

The masking tests with water dilutions of deodorants were repeated on a more extensive basis using fecal material incubated for 24 hours in the absence or presence of representative deodorants, thus simulating use conditions. The results of these tests are presented in Table 7. Warning odors were detected in the presence of fecal matter odor 2.5 to 4 times above threshold, but since untreated samples are more odorous than treated samples, the odor masking caused by them is greater than that of deodorant-treated samples. In deodorant-treated samples, the lowest concentration of malodor which masked detectable warning odors varied from threshold to about 2 times threshold. Apparently any odor that can be detected with ease will decrease the perception of warning odors.

TABLE 5. THE THRESHOLD ODOR AND MASKING POTENTIAL OF DEODORANTS IN WATER

Deodorant			Geometric mean dilution	
Code No.	Dose, g/l	No. of Observers	Deodorant T. O.	Masking dilution
501	5*	2	<30	<30
207	250	17	390	280
602	5*	4	350	350
610	12.5	4	350	350
215	23.4	16	390	375
201	(a)	16	530	500
606	0.25*(b)	4	190	150
209	(a)	17	2600	2540
205	23.4*	17	2800	2650

(a) One gram cake of p-dichlorbenzene compound suspended in sample air.
(b) The dose was about one fifth the recommended dose.
* Milliliters per liter.

TABLE 6. THE THRESHOLD ODOR OF DEODORANTS IN WATER

Deodorant		Threshold odor	
Code No.	Dose, g/l	Obs. A	Obs. B
512	15	<13	<13
513	15	<13	<13
214	23*	160	550
401	40*	330	330
606	5	230	550
206	5*	270	1100
501	5*	420	420
405	5	4100	16,500
500	5	20,000	20,000
406	5	33,000	33,000

* Milliliters per liter.

TABLE 7. MASKING POTENTIAL OF DEODORANT-TREATED FECAL MATERIAL

Warning odor, high test gasoline.

Date	Deodorant		Number of observers	Geometric mean dilution		
	Code No.	Dose g/l		T. O.	Masking dilution	Ratio
5/18	Control		16	27,000	6,600	0.3
	501	6*	18	700	530	0.8
	606	1.2	18	4,200	2,370	0.6
	607	25	19	640	345	0.5
5/19	Control		14	10,000	2,900	0.4
	205	23.4*	20	7,300	4,100	0.6
	401	4*	20	6,000	3,700	0.6
	512	3	20	190	137	0.7
	608	300	19	480	330	0.7
5/20	Control		18	17,400	5,200	0.3
	207	5	12	5,000	4,000	0.8
	510	25.3	14	260	260	1.0
	613	225*	14	1,400	810	0.6

* Milliliters per liter.

OLFACTORY ANAESTHESIA

Olfactory anaesthetic action of deodorants was measured by having an observer sniff a concentrated solution of the deodorant and then determine the time required to recover his ability to smell a concentration of ortho-xylol equal to twice his threshold. Ortho-xylol was selected as a standard odor because xylol-saturated air has a distinctive odor and was conveniently diluted to threshold values by means of the osmometer. The results of the olfactory anaesthesia tests by two observers are presented in Table 4.

The results show that when exposed to a sniff of concentrated deodorant vapor, which may or may not have been very odorous, the observer required an interval of a few seconds to several minutes before he could detect the odor of o-xylol. It is not intended that the results in this table be used to rate the deodorants for olfactory anaesthetic characteristics, since concentrated deodorant solutions were used. Rather, an approach to olfactory anaesthesia evaluation is merely indicated. The method appears promising, but for evaluation purposes multiple observations should be made on use concentrations of deodorant. After each deodorant is tested, it might also be found necessary to redetermine the threshold value for o-xylol to compensate for prolonged anaesthetic effects.

TABLE 8. OLFACTORY ANAESTHESIA FROM SNIFFING DEODORANT CHEMICALS

Deodorant No.	Recovery from anaesthesia, time in seconds Observer A*	Observer B*	Average	Deodorant No.	Recovery from anaesthesia, time in seconds Observer A*	Observer B*	Average
201	35	62	47	505	3	4	3
204	12	6	9	506	4	3	3
206	100	60	80	507	2	8	5
207	4	5	4	508	24	22	23
208	60	120	90	509	5	6	5
211	1	2	1	510	1	4	2
212	25	41	33	511	17	20	18
213	50	65	57	512	18	35	26
214	5	2	3	600	20	40	30
215	12	2	7	601	25	26	25
401	19	23	21	602	130	114	122
402	25	58	41	606	200	115	160
403	36	60	48	607	7	5	6
404	40	110	75	608	4	3	3
405	38	45	40	609	62	84	70
406	200	180+	200	610	60	84	70
500	22	30	26	611	20	65	40
501	25	25	25	612	14	62	40
502	2	3	2	613	3	4	3
504	1	4	2	615	45	65	55

* O-xylol T.O. for Observer A=4300, for Observer B= 2500.
O-xylol dilution used for Observer A=1:2000, for Observer B=1:1300.

SUMMARY OF FINDINGS

The principal deodorant evaluation tests are summarized in Table 9, where deodorants are listed in approximate order of decreasing odor control factor (column 5). Of the first five listed, which had odor control factors of 45 to 100, Nos. 504, 512, and 516 underwent changes during shelf stability tests, and No. 512 compared less favorably with respect to olfactory anaesthesia. Deodorant No. 214 was liquid in bulk form, and No. 101 was a powder which in water solution was slightly corrosive to aluminum.

The six next most effective deodorants, which had odor control-factors of 10 to 25, included a large dose of urea (No. 608), a chemical which has poor shelf stability, and three quaternaries, Nos. 506, 507, and 510. Sodium hypochlorite, No. 211, was somewhat corrosive. No. 607, a chlorophyll compound, was moderately satisfactory.

The remaining deodorants tested were found to be less effective, having odor control factors of less than 10, and some had unfavorable olfactory anaesthesia characteristics.

DISCUSSION

The ratings listed in Table 9 are based on application of a particular dosage of chemical to approximately 3 per cent fecal matter. Should the loading of fecal matter exceed 3 per cent, a proportionately greater dosage of deodorant presumably would be needed to control the odor. As shown in Table 3, only a few of the deodorants appear to deodorize the malodor of incubated fecal matter. Stated differently, deodorants are largely effective by preventing the formation of odors during the 24-hour incubation period. If the disinfectants (such as the quaternaries) are neutralized by organic matter, then incremental deodorant dosages, or dosages proportional to the fecal load, would be required.

The studies on methods of evaluating deodorant chemicals for odor control in aircraft toilets appear promising but lack confirmation by tests in aircraft use. Such information is necessary for the establishment of threshold odor values or odor control factors that will provide adequate odor control. In field tests, chemicals that permit the presence of odors characteristic of the source material, chemical agent, or a combination of the two (source material and agent) will probably be unsuitable, since any odor will tend to mask warring odors. Furthermore, chemicals that produce olfactory anaesthesia at use concentrations should be avoided, since deterioration of odor perception should not be tolerated.

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TABLE 9. SUMMARY OF TESTS OF DEODORANTS

**

1	2	3	4	5	6	7	8	9
Deodorant			Olfactory anaesthesia recovery, seconds	Odor-control tests			Physical and Chemical tests	
Code No.	Active Agent	Dose, g/l		Control factor	T. O. dilution	Masking dilution	Shelf stability	Corrosion rate
101	$NaBO_2 \cdot H_2O_2$	25	-	100	90	-	I	30
516	Urea & quat.	10	-	90	100	-	II	-
214	Iodine complex	9.3	3	50	170	-	I	4-12
512	Quat.	3	26	47	190	130	IV	0-2
504	"	3	2	45	200	-	II	-
506	Quat.	3	3	24	380	-	I	4-15
510	"	25.3	2	23	390	260	I	10
608	Urea	300	3	20	450	330	VII	9
211	Hypochlorite	12.6	1	24	680	-	I	57
507	Quat.	3	5	15	580	-	I	15
607	Chlorophyl	3	6	12	720	340	I	0-2
501	Quat.	6*	25	9	980	530	I	0-2
613	Unknown	225 *	3	6	1,400	800	I	0-5
606	"	1.2*	160	3	3,600	2,400	I	0-2
207	Chloromelamine	5	4	2	4,700	4,000	I	-
401	Cresylate soap	4*	21	2	6,000	3,700	-	0-2
205	Chlorobenzene	23.4*	-	1	7,300	4,100	1	10-40

* Milliliters per liter.

** Columns 2, 8, and 9 from Table 1.
Columns 3 and 6 from Table 4.
Columns 4 from Table 8.
Column 5 from Table 4.
Column 7 from Table 7.

Odor control factor I was devised in order to take into account variations in source material. It appears, however, that the T.O. of incubated source material varies greatly with many factors such as diet, concentration of source material, rate of bacterial multiplication, etc. The source material, when treated with an effective deodorant, does not give rise to odors of incubation. Consequently the use of an odor control factor based on widely varying controls may give rise to fictitious evaluations of effectiveness. For this reason the source material and its incubation environment should be standardized as much as possible for test purposes.

Although a homogenized mixture of ground meat, eggs, water, and sewage was a convenient and useful source material for preliminary screening of deodorants for effectiveness in controlling odor, discrepancies were found which indicate that human fecal material mixed with urine and water would be more reliable. Suitable control samples are necessary to establish a base line threshold level. Tests made on source material whose control varies widely from the base line range should be disregarded, because the odor control factors will be unduly altered. Had time permitted further investigation, thickened domestic sewage sludge from a primary settling tank might have proved a satisfactory alternative source material.

CONCLUSIONS AND RECOMMENDATIONS

Two threshold odor dilution methods and two malodor source materials were investigated for usefulness in testing the effectiveness of deodorant-chemicals in controlling odor from latrine buckets. The air dilution technic, which utilized an osmometer, was found to be the more reliable and versatile procedure. With the osmometer, compensation may be made for the varying olfactory sensitivity of the odor panel members by comparison with a standard odor. Also olfactory anaesthesia, the masking of warning odors, and the odor control properties of use concentrations of deodorant can be evaluated. Because of its simplicity, the test for olfactory anaesthesia is recommended for preliminary screening purposes.

Shelf stability tests should include odor control tests since deterioration of deodorants without physical evidence is possible.

For the periodic evaluation of deodorant chemicals it is suggested that a more suitable osmometer for simultaneous observations by a panel of four or more members could be constructed using rotameters instead of a Brittingham pump. A volume of odor-free humidified dilution air under slight pressure would be admitted to a battery of four or five sniff cups. A portion of the dilution air would be bypassed to a battery of vari-capacity rotameters for sample air. Each

rotameter of appropriate capacity would be provided with on-off as well as needle valves for rapid adjustment of flow to obtain the desired dilutions of 25, 50, 100, 200, 400, 800, 1600, 3200, 6400, 12,800, 25,600, and 51,200 volumes of odor-free air to one volume of sample air. This air would displace sample air from an appropriate sample flask into the dilution air header of the sniff cups.

A second or duplicate train of rotameters covering a range of threshold dilutions from 400 to 6400 for admitting a standard odor such as o-xylol into the sniff cups would provide a simple and effective method for frequent checking of the perception capabilities of individual observers. Comparison of the perception by a given observer of sample odors to a "normal" perception level could then be made. This same "standard" would also provide means of evaluating olfactory anaesthesia. It could also be used to test the masking of warning odors by deodorants, since it appears that any foreign odor tends to mask alarm odors, and o-xylol may be used as a synthetic alarm odor.

Preliminary specifications for deodorant evaluations could be prepared on the basis of these investigations, but it would be highly desirable to make field tests on the effectiveness of a select few deodorants to establish the threshold odor level or odor control factor satisfactory in practical use.

Further evaluations, using fresh waste materials, should be made on the more promising deodorants to study such factors as the dissolution of semisolid material, the penetration of disinfectants into semisolid material, the deterioration of disinfectants by organic matter, and the bacterial seeding with each deposition, any of which might materially alter the effectiveness of particular deodorants during the period in which odor was to be controlled.

REFERENCES

1. Aero Medical Laboratory, WCRDB, "Exhibit on Evaluation of Deodorant, Disinfectant Chemicals," Wright Air Development Center (March 1954).

2. Kuehner, R. L., "The Validity of Practical Odor Measurement Methods," Annals of N. Y. Acad. Sci., 58, Art. 2, 175 (1954).

3. Setter, L. R., Brittingham, W. E., and Wessels, R. F., "The Brittingham Laboratory Pump," Sewage and Ind. Wastes, 25, 798 (1953).

4. Spealman, C. R., "Odor, Odorants, and Deodorants in Aviation," Annals of the N. Y. Acad. Sci., 58, 41 (1954).

5. Standard Methods for the Examination of Water, Sewage and Industrial Wastes, Am. Public Health Assoc., 10th Edition (1955).

6. Uhlig, H. H., Corrosion Handbook, p. 1077, John Wiley and Sons (1948).

APPENDIX I

METHOD OF DETERMINING THE CORROSIVITY OF DEODORANT-CHEMICALS TO ANODIZED ALUMINUM

A gravimetric method utilizing Knapp's procedure[6] of cleaning and preparing specimens was adapted for tests of corrosivity. Numbered strips of anodized aluminum (each 10.3 x 1.3 x 0.1 cm, having an average surface area of 29.5 cm^2 and weighing from 3.60 to 3.68 grams) were furnished by the Engineering Section, Aero Medical Laboratory, Wright Air Development Center. The strips were first cleaned by immersing in an acetone-ether solvent, then dried in an oven at 103°C for 30 minutes and weighed. A strip was then placed in 30 ml of agent in a test tube (155 x 22 ml dia.) so as to leave 15 per cent of the aluminum strip above the solution surface.

The samples were stored at 20° C in an incubator for 70 to 110 days before determining the loss of weight. The strips were periodically inspected for gross signs of corrosion and evaporation. Distilled water was added to maintain a constant level in the exposure tubes. After storage, the strips were removed from the test tubes, rinsed in running tap water, washed in acetone if coated with organic agents, and oven-dried. The strips were then immersed in concentrated nitric acid at room temperature for 3 minutes, scrubbed lightly with a bristle brush under running tap water to remove film, dried in an oven at 103°C for 5 minutes, and weighed. The total loss of weight of aluminum metal of the test strip, less the mean loss of weight of control strips in distilled water, was prorated to the net loss of weight in milligrams per strip per 100 days of exposure. The control strips lost from 0 to 10 milligrams in 100 days exposure.

APPENDIX II

COPY OF AN INVITATION TO SUBMIT DISINFECTANT, DEODORANT CHEMICALS

HEADQUARTERS
WRIGHT AIR DEVELOPMENT CENTER
WRIGHT PATTERSON AIR FORCE BASE, OHIO

WCRDE-2

SUBJECT: Disinfectant, Deodorant Chemicals

TO:

1. The Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, with the help of the U. S. Public Health Service, Cincinnati, Ohio, plans to review the problem of disinfecting and deodorizing chemical toilets aboard aircraft. The study is estimated to commence in May 1954. The test program will include screening of currently available commercial products followed by a more thorough evaluation of the most promising of these products. These test results will be used in the preparation of an Air Force specification based on appropriate performance characteristics.

2. Your company is invited to submit a sample of your product(s) having the following performance characteristics for screening. You may also submit new formulations which may have applications to this problem.

a. The product, its solution or vapors, should not be corrosive to metals.

b. The product should be effective in suppressing fecal odors in the temperature range of 30°F to 130°F and for prolonged periods extending to as long as 24 hours after charging.

c. The product or its vapors should not be a lachrymator, or irritating to the skin or mucous membranes.

d. The product should preferably be in tablet form or at least should be capable of being formed into tablets.

Hq WADC (WCRDE-2) Subject: "Disinfectant, Deodorant Chemicals"

3. Approximately one pound of each product will be required. These products may be shipped directly to: Robert A. Taft Sanitary Engineering Center, U. S. Public Health Service, 4676 Columbia Parkway, Cincinnati 26, Ohio, attention Lt. Lagnese. It is also requested that the chemical composition, formulations, and other pertinent information including present uses, cost, and results of previous tests, be furnished for each product with the understanding that this information will be kept confidential. All results obtained by this Center on your product will, in turn, be forwarded to you. Please submit these samples before 1 June 1954. It is requested that any inquiries concerning this project be directed to Commander, Wright Air Development Center, Wright Patterson Air Force Base, Ohio, attention: WCRDE-2.

4. This invitation does not constitute a procurement action by this Center or in any way obligate the United States Government. Your interest and cooperation in this program is sincerely appreciated.

FOR THE COMMANDER:

(signed) Charles L. Wilde

CHARLES L. WILDE
Acting Chief, Engineering & Development Branch
Aero Medical Laboratory
Directorate of Research

APPENDIX III

THE OSMOMETER

The principles of odor measurement as reviewed by Kuehner[2] were followed in assembling an osmometer suitable for the task of evaluating deodorant chemicals by the air dilution technic.

A photograph (Figure 2) and a flow diagram (Figure 3) show the general features of the apparatus. Referring to Figure 2, item 1, the air cleaning column for supplying odor-free dilution air is a 4-inch i.d. stainless steel pipe 3 feet in length, packed from bottom to top with 6 inches of glass wool, 18 inches of granular activated carbon (Nuchar No. 190), 6 inches of diatomaceous earth, and another 6 inches of glass wool. Laboratory compressed air (20 p.s.i.) is admitted at the bottom of the filter and is controlled through a regulator (item 2) to yield the desired flow in a rotameter (item 3) of 28.3, 14.1, or 7 liters per minute. The air is then bubbled through a head of 1/2 inch of water in a 500-ml erlenmeyer flask for humidification and passed thence into the sniff cup (item 8).

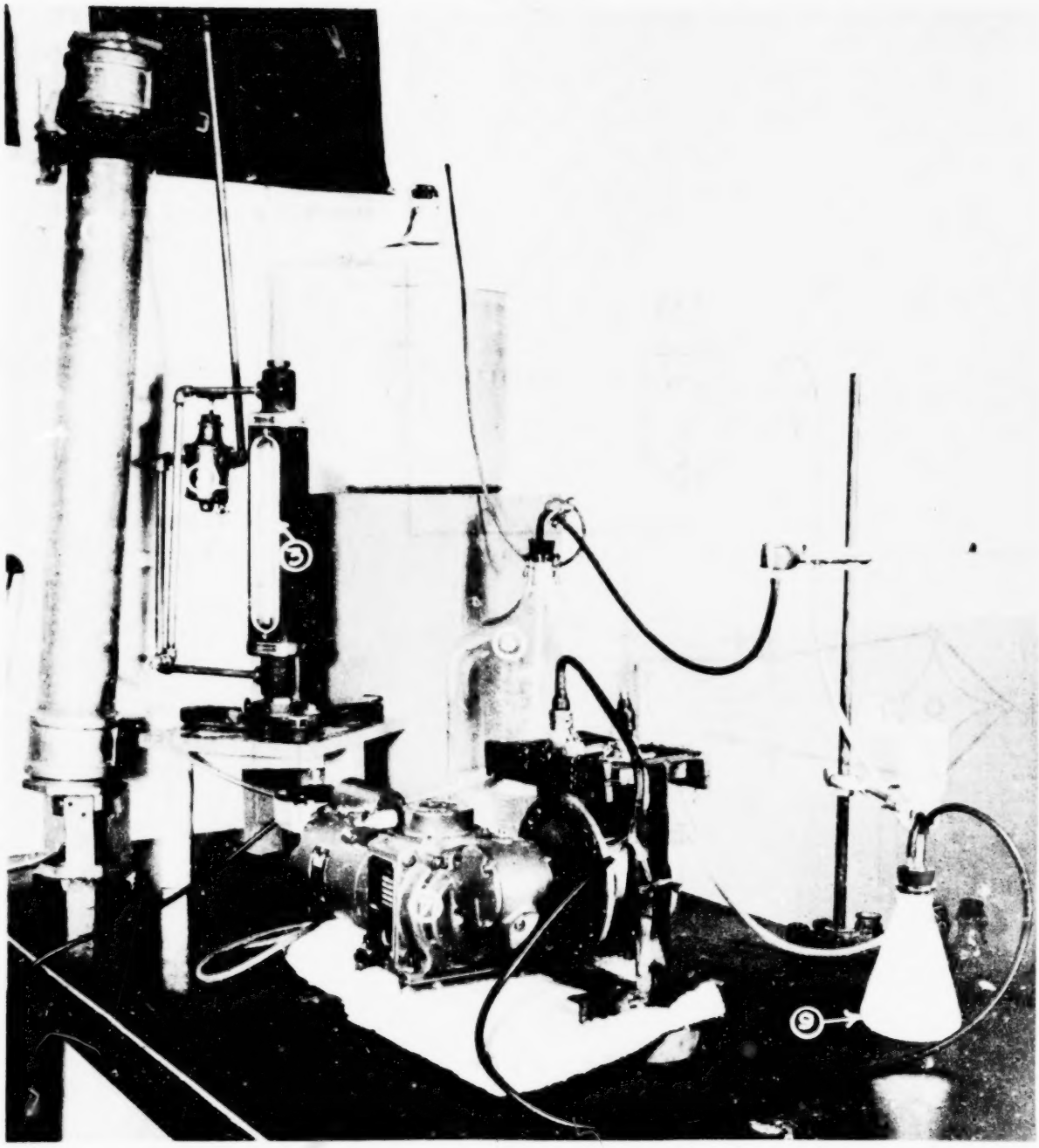
The malodorous air is injected into the dilution air stream through a hypodermic needle by means of a Brittingham pump[3] coupled to a variable-speed Graham transmission (item 7). The malodorous sample of 200 ml in a 500-ml erlenmeyer flask is placed in the pump air train of 1/4-inch Scimatco rubber tubing with an inlet glass tube extending just below the liquid level of the sample and the outlet within 3 inches of the hypodermic needle.

The Brittingham pump utilizes four 5/16-inch steel rollers spaced equidistant from each other and supported on ball-bearings in end flanges. The distance on centers between the rollers and the main shaft of the pump drive is 3 inches. Approximately 17 inches of Scimatco tubing, exclusive of connections, is stretched around three of the four rollers and fastened to a steel frame 5-1/2 inches distant from the main shaft center, with the inlet and exhaust tubes spaced 4-1/2 inches apart. A balance was used to adjust the tautness of the rubber tubing to assure positive displacement for the gas pressure anticipated. For Scimatco tubing 1/4-inch diameter x 3/32-inch wall thickness, a tautness equal to 1.8 kg was used, and for tubing 1/8-inch diameter x 1/16-inch wall thickness, 0.6 kg.

A calibration of the Brittingham pump using 1/4-inch diameter x 3/32-inch wall thickness tubing with 1.8 kg tension, and with the tubing lightly lubricated with silicon grease, is presented in Table 10 and Figure 4.

The importance of standardizing an observer's perception to odors is shown in Table 11, where a two- to four-fold variation in the threshold odor of ortho-xylol appears commonplace.

FIGURE 2

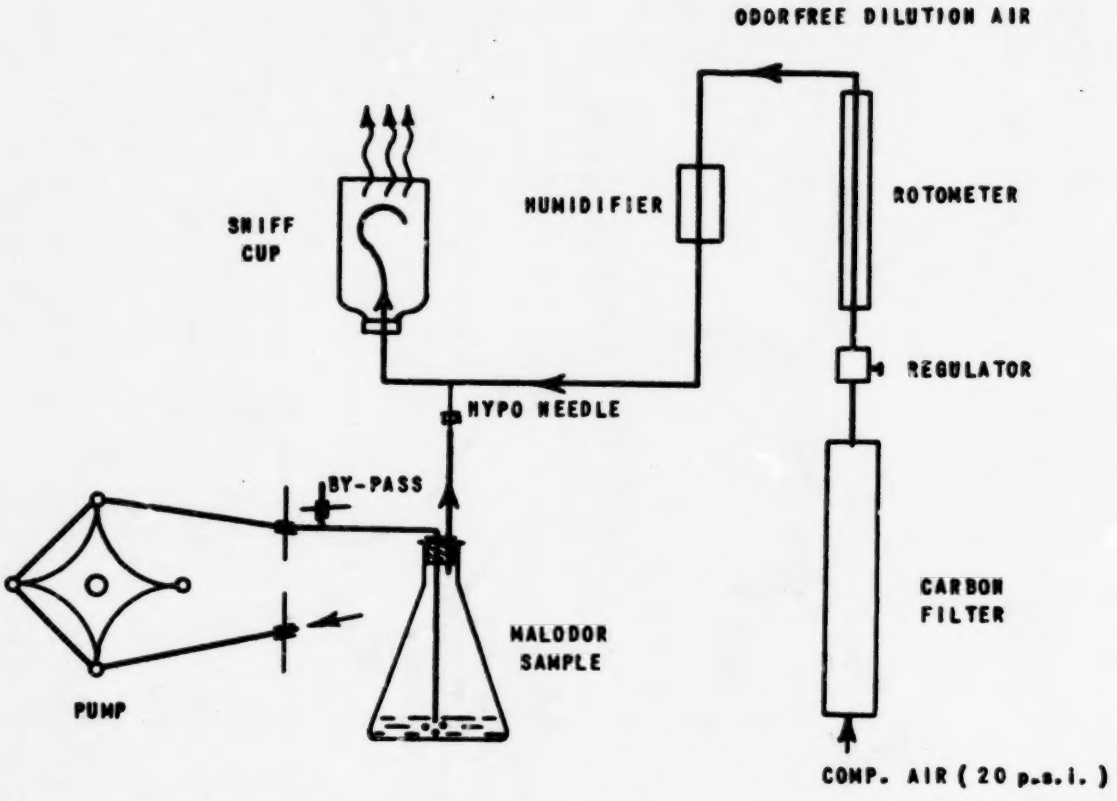


1. Activated Carbon Filter. 2. Pressure Regulator. 3. Rotometer.
4. Displacement Water (Warning Odor). 5. Rotometer (Warning Odor). 6. Warning Odor.
7. Variable Transmission Drive. 8. Sniff Port. 9. Malodor

OSMOMETER, DISINFECTANT DEODORANT CHEMICAL STUDY.

WADC Photo

FIGURE 3



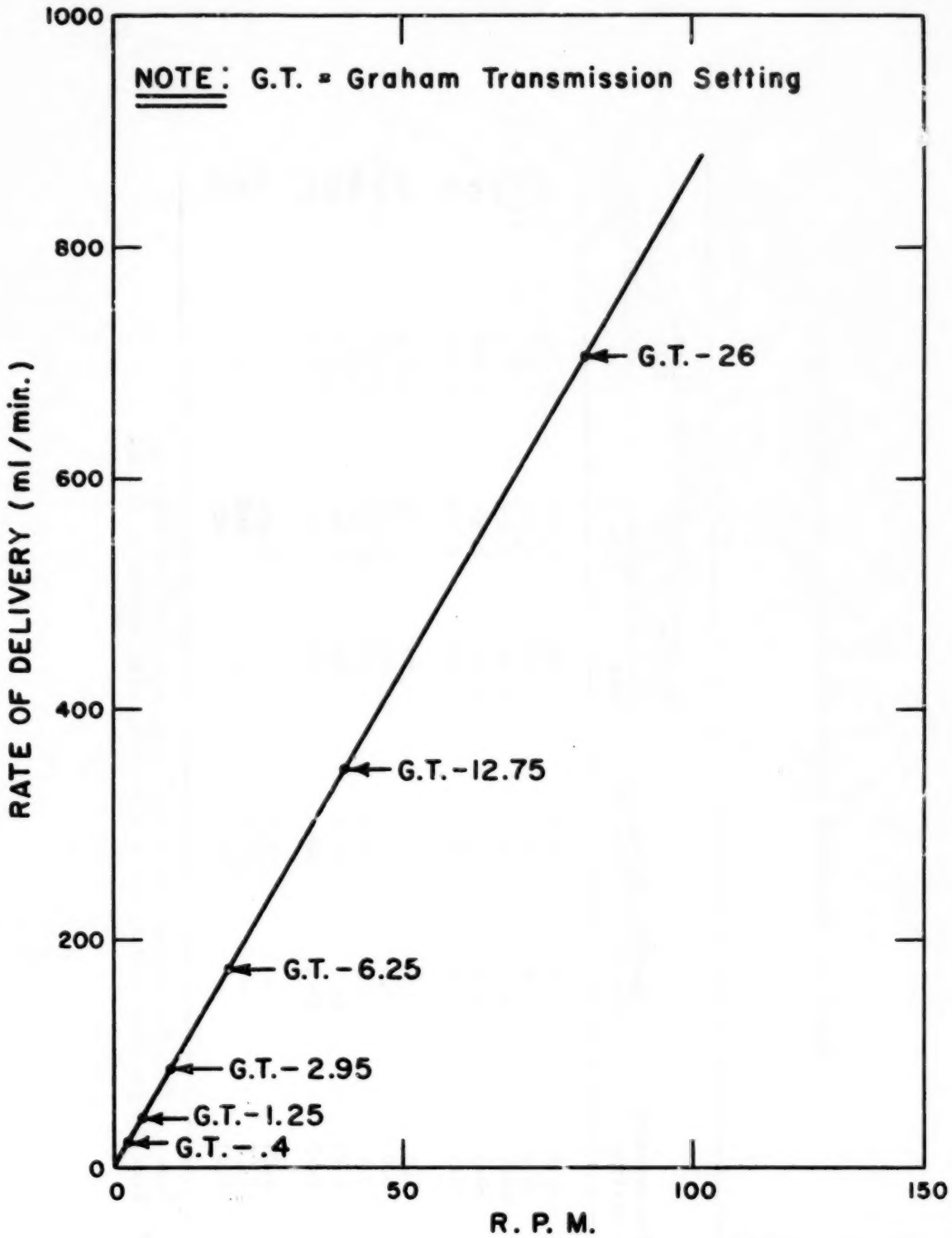
OSMOMETER FLOW DIAGRAM

TABLE 10. CONVERSION OF OSMOMETER READINGS TO THRESHOLD VALUES

Transmission setting	Melodor, ml/min		Threshold odor values			
			Dilution air flow 28.3 liters/min		Dilution air flow 12.9 liters/min	
	Tube 1*	Tube 2**	Tube 1	Tube 2	Tube 1	Tube 2
-0.2	1.0	6.5	28,000	4,300	13,000	1,500
-0.1	1.9	9	15,000	2,500	6,800	1,400
+0.1	3.0	14	9,400	2,000	4,300	900
+0.3	4.4	18	6,400	1,500	3,000	700
+0.5	6.0	24.7	4,700	1,000	2,100	520
1.0	9.4	37.5	3,000	750	1,400	340
0.0	2.4	11.0	11,800	2,600	5,400	1,200
0.4	5.1	21.5	5,500	12,800	2,500	600
1.25	11.0	44.0	2,600	6,400	1,200	300
2.95	23.0	86.0	1,200	3,300	560	150
6.25	-	172.0	-	1,650	-	75
12.75	-	350.0	-	800	-	30
26.00	-	702.0	-	400	-	14

* Tube 1 = Scimatco tubing, 1/8 x 1/32 inch, with tension of 0.6 kg.
** Tube 2 = Scimatco tubing, 1/4 x 3/32 inch, with tension of 1.8 kg.

FIGURE 4



CALIBRATION CURVE FOR ODOR SUPPLY PUMP

TABLE 11. OSMOMETER THRESHOLD ODOR OF ORTHO-XYLOL STANDARD

Time of observation	Observer					
	A	B	C	D	E	F
Early morning	1150	930	1750	1500	2500	870
Late morning	3100	-	1750	2500	1750	2500
Early afternoon	-	4300	4300	4300	2500	7000
Late afternoon	1150	3100	1150	3100	2500	
Early morning	1300	2500				
Mid-morning	2500	900				
Late morning	1150	1300				
Early afternoon	1300	-				
Late afternoon	1300	-				
Early morning	1300	4300				